America to the effect that so long as the volcanoes in their neighborhood were active, no danger from earthquakes need be feared, but if they remained quiescent for a long-continued period severe earthshocks might be anticipated. In a manner the volcano acted as a safety valve, according to the tradition. The presence of an active volcano in California naturally invited an investigation to determine whether or not it was related to earthquakes.

Of the 225 or more observed eruptions of Lassen Peak to date, there is no authentic record of a single sensible earthquake occurring in northern California simultaneously with such an outburst. Press dispatches at various times have announced the occurrence of destructive shocks at the times of these eruptions, but when subsequently investigated none of these reports could be verified. Shortly before the first outburst of Lassen Peak, in May, 1914, a moderate shock occurred in the vicinity of Lassen; two other shocks occurred during 1915. This is about the average frequency, and since none of these occurred on days of eruptions it is believed that they were of tectonic origin, like most California earthquakes. United States forest rangers on duty in the vicinity of Lassen at the times of eruptions heard the escaping steam and the falling stones, but reported no rumbling or subterranean noises, nor did they feel any earthquakes. A letter recently addressed to the United States forest supervisor at Mineral, 10 miles from Lassen Peak, brought the following reply:

> Several very slight earthquake shocks were felt here last summer (1915) and in 1914. They did not, however, occur simultaneously with eruptions of Lassen Peak, and to the best of our knowledge there is no relation between earthquakes and volcanic eruptions in this vicinity. It is true, of course, that the ground in the near vicinity of the mountain is felt to tremble slightly during a violent eruption, but it is doubtful if this is a true earthquake shock.

It is probable that the latter tremors are simply local vibrations similar to those produced by the passage of a railroad train and are therefore not earthquakes in the usual sense.

The cause of the present activity of Lassen Peak is now believed to be the immeasurable pressure of expanding lava rising from below and not the explosive action of steam, as in the case of some other volcanoes. Figure 10 is a photograph of the crater of Lassen Peak taken by Mr. B. F. Loomis on June 20, 1914. Prof. Holway finds it difficult to conceive of steam pressure uplifting so evenly a broken and jagged mass of rock. Diller believes that, although the visible activity is limited to near the summit of the peak, the new lava was forced in a hot, viscous state to the surface, where it spread and overflowed the crater rim. Hot springs and solfataras in the vicinity of the Peak show no evidence of increased activity.

CONCLUSION.

The present cycle of Lassen Peak's activity as a volcano appears to be about complete. While future eruptions will be observed with interest, it is believed that they will be relatively feeble and infrequent. An active volcano in the United States is such a rare phenomenon that it is worthy of careful observation from every point of view. While an active volcano is of primary interest to the geologist and the physiographer, it is of at least secondary importance to the meteorologist and the seismologist. Progress in every field demands the recording of all observations available. Those facts of peculiar interest in meteorology and seismology have been collected and reassembled in the foregoing.

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Its physics and chemistry are now being studied by A. L. Day and E. S. Shepherd, of the Geophysical Laboratory, Carnegie Institution of Washington, and will be described in a forthcoming report.

A NEW METHOD FOR DETERMINING "g" THE ACCELERATION DUE TO GRAVITY.

By HERBERT BELL, Dept. Physics, University of Michigan.

[Read before the American Physical Society, Chicago, Ill., Dec. 2, 1916.]

Consider a compound pendulum consisting of a nut of mass m, movable along a screw rod of mass M, the whole oscillating in a vertical plane about a central axis of suspension O. Denote by MK^2 the inertia of the rod about O, by mk^2 that of the nut about its center of gravity g, and by b_n the distance between O and g as projected along the rod. Suppose further that the point g is not quite collinear with the axis of the rod, but is a small distance u from this line. Then, neglecting the buoyancy and resistance of the air, we have the differential equation of motion

$$(MK^2+mk^2+mu^2+mb_n^2)d^2\theta/dt^2$$
$$= -Mhg \sin\theta - mg\, b_n \sin(\theta-\alpha_n) - C\theta,$$

where $\tan\alpha_n = u/b_n$. C is the restoring couple due to the suspension, and h the distance between O and G.

The effect of the air is twofold: (1) on account of buoyancy the restoring couple due to the weight is slightly reduced so that we must replace M and m on the right hand side of our equation by M' and m', slightly smaller quantities; (2) on account of the dragging effect these quantities on the left side must be slightly increased, say, to M'' and m'', we then have

$$(M''K^2+m''k^2+m''u^2+m''b_n^2)d^2\theta/dt^2$$
$$= -M'hg \sin\theta - m'gb_n \sin(\theta-\alpha_n) - C\theta.$$

Now the proposal is to take the time of swing T_n for various positions b_n of the nut along the screw. Thus all the constants in this equation except b_n and α_n are absolute constants. C is in any case to be very small in comparison with $M'hg$ or mb_ng.

Let us now simplify this equation by writing new constants in place of groups of constants and assuming that cubes of θ and α_n may be neglected. We thus have after dividing throughout by m''

$$(A'+b_n^2)d^2\theta/dt^2 = -\frac{M'h+m'b_n+c}{m''}g\theta + \frac{m'b_ng\alpha_n}{m''}$$

$$= -\left(B'+\frac{m'}{m''}b_n\right)g\theta + \frac{m'}{m''}g\alpha_nb_n$$

The period of oscillation, T'_n, is therefore given by

$$T'^2_n = \frac{4\pi^2(A'+b_n^2)}{\left(B'+\frac{m'}{m''}b_n\right)g} \quad .$$

There is, however, a further correction if we take into account the logarithmetic decrement λ due to the decreasing amplitude of swing in a resisting medium.

We then have, neglecting λ^4 and higher powers:

$$T_n^2 = \frac{4\pi^2(A'+b_n^2)}{\left(B'+\frac{m'}{m''}b_n\right)g}\left(1+\lambda^2\frac{T'^2_n}{4\pi^2}\right)$$

Multiplying, and writing F_n for $1+\lambda^2\frac{T'^2_n}{4\pi^2}$, sensibly equal to $1+\lambda^2\frac{T_n^2}{4\pi^2}$, and putting $b_n=b_0+p_n$ we have

$$\left(B'+\frac{m'}{m''}b_0+\frac{m'}{m''}p_n\right)T_n^2g = 4\pi^2(A'+b_0^2+2b_0p_n+p_n^2)F_n.$$

Now when $n=0$ let $b=b_0$ so that $p_0=0$.

Therefore

$$\left(B'+\frac{m'}{m''}b_0\right)T_0^2g = 4\pi^2(A'+b_0^2)F_0.$$

Therefore subtracting, we have

$$\left(B'+\frac{m'}{m''}b_0\right)\left(T_n^2-T_0^2\right)g+\frac{m'}{m''}p_nT_n^2g$$
$$=4\pi^2(A'+b_0^2)(F_n-F_0)+8\pi^2b_0p_nF_n+4\pi^2p_n^2F_n$$

or

$$B(T_n^2-T_0^2)-8\pi^2b_0p_nF_n+\frac{m'}{m''}p_nT_n^2g-4\pi^2p_n^2F_n=0.$$

Giving n the successive values 1, 2, 3, and eliminating B and b_0 from the resulting three equations we have

$$\begin{vmatrix} T_1^2-T_0^2 & p_1F_1 & \frac{m'}{m''}p_1T_1^2g & -4\pi^2p_1^2F_1 \\ T_2^2-T_0^2 & p_2F_2 & \frac{m'}{m''}p_2T_2^2g & -4\pi^2p_2^2F_2 \\ T_3^2-T_0^2 & p_3F_3 & \frac{m'}{m''}p_3T_3^2g & -4\pi^2p_3^2F_3 \end{vmatrix}=0$$

or

$$g=\frac{m''}{m'}4\pi^2\begin{vmatrix} T_1^2-T_0^2 & p_1F_1 & p_1^2F_1 \\ T_2^2-T_0^2 & p_2F_2 & p_2^2F_2 \\ T_3^2-T_0^2 & p_3F_3 & p_3^2F_3 \end{vmatrix} \div \begin{vmatrix} T_1^2-T_0^2 & p_1F_1 & p_1T_1^2 \\ T_2^2-T_0^2 & p_2F_2 & p_2T_2^2 \\ T_3^2-T_0^2 & p_3F_3 & p_3T_3^2 \end{vmatrix}$$

g is thus completely determined by the four sets of measurements at p_0, p_1, p_2, p_3, indicated by these determinants provided λ and $\frac{m''}{m'}$ be independently calculable.

As regards the F's, which depend on λ, we can proceed as is usual in the present methods, viz: Observe the rate of fall of amplitude of swing or, better, we can attach an electric mechanism which gives an impulse at the bottom of each swing. In this case $\lambda=0$ and the F's each $=1$.

As regards $\frac{m''}{m'}$: $m''=m(1+f\rho'/\rho)$, where ρ' = density of air, ρ is that of pendulum, and f is some constant of the order of unity; also $m'=m(1-\rho'/\rho)$. Therefore

$$\frac{m''}{m'}=1+(1+f)\ \rho'/\rho=1+\beta\rho'$$

where β is constant. Thus

$$g=4\pi^2(1+\beta\rho')M,$$

where M is the ratio of the two determinants.

To take account of the small correction $\beta\rho'$ we must therefore carry out our sets of readings in air of two different densities, say, ρ_1' and ρ_2', $\rho_1'>\rho_2'$. This does not affect the F's (logarithmic decrement). If M_1 and M_2 are the corresponding determinantal values we easily find

$$g=M_2\left(1-\frac{\rho_2'}{\rho'}\right)\left(1-\frac{M_2}{M_1}\frac{\rho_2'}{\rho_1'}\right)^{-1}$$
$$=M_2\left\{1+\frac{M_2-M_1}{M_1}\cdot\frac{\rho_2'}{\rho_1'}+\frac{M_2}{M_1}\cdot\frac{M_2-M_1}{M_1}\left(\frac{\rho_2'}{\rho_1'}\right)^2\right.$$
$$\left.+\frac{M_2^2}{M_1^2}\cdot\frac{M_2-M_1}{M_1}\left(\frac{\rho_2'}{\rho_1'}\right)^3+\text{etc.}\right\}$$

Therefore, since M_1 and M_2 are very nearly equal we find that the error in the determination of g due to that in measuring $\frac{\rho_2'}{\rho_1'}$ is given by approximately

$$\delta g=\left(M_2-M_1\right)\left\{1+2\frac{\rho_2'}{\rho_1'}+3\left(\frac{\rho_2'}{\rho_1'}\right)^2++\right\}\delta\left(\frac{\rho_2'}{\rho_1'}\right)$$
$$=\left(M_2-M_1\right)\left(1-\frac{\rho_2'}{\rho_1'}\right)^{-2}\delta\left(\frac{\rho_2'}{\rho_1'}\right) \quad .$$

Considering the accuracy with which the barometer can be read this is easily seen to be much less than other and instrumental errors.

The error in g is thus directly proportional to the air density, and by working at two different densities we can find the error, which is in any case a very small quantity.

The suspension should consist of a flat spring very flexible and fastened to a support so rigid that there is no correction needed on that score.

The distances p_n can be measured with great accuracy by any of the modern methods (interference, etc.).

It is essential that the distances p_n be the distances between whole turns of the screw, otherwise the inertias are not constant.

The advantages of the proposal here outlined are: No measurements except of length p_n and time T_n and barometric pressure; no corrections for knife edges or movement of support or rigidity of spring; no calculations of inertia (see *Pellat* in C. R., Nov., 1909).

The pendulum should, of course, be made of invar and be worked at a constant temperature.

Any four sets of readings give us a determination. By multiplying these at various positions along the rod we increase the accuracy and detect any error due to inequalities, etc.